1 Density functional for DH model

Let's consider mixture of charged spherical particles with negligible size and charges ± 1 Let densities of a bulk particles are ρ_+^0 and ρ_-^0. Let the mixture be electoneutral. Then $\rho_+^0 = \rho_-^0 = \rho^0$.

Let the density distributions of anions and cations be $\rho_-(\mathbf{r})$ and $\rho_+(\mathbf{r})$ respectively.

In a general case density functional for two-component mixture is:

$$\mathcal{F}[\rho_+, \rho_-] = \int \rho_+(\mathbf{r})(\ln \Lambda^3 \rho_+(\mathbf{r}) - 1)d\mathbf{r} + \int \rho_-(\mathbf{r})(\ln \Lambda^3 \rho_-(\mathbf{r}) - 1)d\mathbf{r} + \int \rho^{(N)}(\mathbf{r^N}) U_N(\mathbf{r^N}) d\mathbf{r^N} \quad (1)$$

In a case of pairwise potential we have:

$$\int \rho^{(N)}(\mathbf{r^N}) U_N(\mathbf{r^N}) d\mathbf{r^N} = \sum_{i<j} \int \rho^{(N)}(\mathbf{r^N}) u(|\mathbf{r_i} - \mathbf{r_j}|) d\mathbf{r^N} = \frac{1}{2} \int \int u(|\mathbf{r_1} - \mathbf{r_2}|) \rho^{(2)}(\mathbf{r_1}, \mathbf{r_2}) d\mathbf{r_1} d\mathbf{r_2} \quad (2)$$

Let's consider, particles densities are independent (ideal gas consideration):

$$\rho^{(2)}(\mathbf{r_1}, \mathbf{r_2}) = \rho(\mathbf{r_1})\rho(\mathbf{r_2}) \quad (3)$$

Also we make a consideration, that particles are interacting only via the Coulomb potential we rewrite (**??**) as:

$$\mathcal{F}[\rho_+, \rho_-] = \int \rho_+(\mathbf{r})(\ln \Lambda^3 \rho_+(\mathbf{r}) - 1)d\mathbf{r} + \int \rho_-(\mathbf{r})(\ln \Lambda^3 \rho_-(\mathbf{r}) - 1)d\mathbf{r} - \frac{e^2}{2} \left(\int \frac{\rho_+(\mathbf{r})\rho_+(\mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|} d\mathbf{r} d\mathbf{r}' + \int \frac{\rho_-(\mathbf{r})\rho_-(\mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|} d\mathbf{r} d\mathbf{r} \right. \quad (4)$$

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